APPENDIX I
DESIGN EXAMPLE FOR THERMAL DESORPTION ACTIVITIES

1. Overview. Following is a typical approach and basic information that is useful for design considerations and decisions for a thermal desorption application.

2. Quantity. Determine the quantity of soil in place requiring treatment.

Given:

- A site with soils contaminated with polyaromatic hydrocarbons. An investigation consisting of soil borings and analytical sampling was conducted at the site to delineate the areas of contamination. Based on information collected from the site investigation, the site has been divided into the following discrete areas of contamination:

Area No.	Dimensions	Depth of Contamination
1	76.2 m X 76.2 m (250 ft X 250 ft)	0.6 m (2 ft)
2	76.2 m X 76.2 m (250 ft X 250 ft)	6.1 m (20 ft)
3	76.2 m X 61 m (250 ft X 200 ft)	0.6 m (2 ft)
4	36.6 m X 137.2 m (120 ft X 450 ft)	0.6 m (2 ft)
5	45.7 m X 45.7 m (150 ft X 150 ft)	5.5 m (18 ft)
6	15.2 m X 15.2 m (50 ft X 50 ft)	0.6 m (2 ft)

Solution:

- In-Place Volume of Contaminated Material(soil): 56,600 m^3 (74,000 cy)

3. Unit Treatment Time. Determine the treatment time for an on-site thermal desorption unit to desorb the organic contaminants from the contaminated material, collect and condense the organic vapor.

Given:

- 56,600 cubic meters (74,000 cy) of contaminated material
- Unit process rate of 81,600 kg/day (90 ton/day)
- Down time of 30%
- Density of contaminated material 1780 kg/m^3 (1.5 ton/cy)

Assumptions:

- Feasibility study of site identified in (a) concluded on-site thermal desorption most effective technology for remediating 56,600 m^3 (74,000 cy) of contaminated material.
- Contractor submitting the lowest bid will utilize a thermal desorption unit capable of processing 81,600 kg/day (90 ton/day) of contaminated material.
- Density of contaminated material is 1780 kg/m^3 (1.5 ton/cy)
- Functional operation of the unit is 70% of rated capacity.

Solution:

- 100.748 X 10^6 kg (111,000 ton) contaminated material; [(100.748 X10^6 kg)/(81,600 kg/day)] = 1,234 days without downtime. Including downtime: 1,234 days * 1.3 = 1,604 days
- Treatment time for thermal desorption unit: 54 months

4. Unit Power Requirement. Determine the power requirement to thermally desorb 100.748 X 10^6 kg of contaminated material. Contaminant to be thermal desorbed: benzo(a)anthracene.

Given:

- Process rate of 81,600 kg/day (90 ton/day)
- Water content of soil 25%
- Boiling point of benzo(a)anthracene 435°C (815°F)

- Initial Temperature of Soil 20°C (68°F)
- Specific heat of soil 200 cal/kg°C
- Specific heat of water 1000 cal/kg°C
- Installation of heat recovery limited by temporary nature of system

Solution:

- Energy to heat 1 kg of soil to 100°C
  (1 kg)(100°C-20°C)(200 cal/kg°C) = 16,000 cal
- Energy to heat water (at 25%) to 100°C
  (0.25 kg)(100°C-20°C)(1000 cal/kg°C) = 20,000 cal
- Energy to boil off water
  (0.25 kg water)(5.4 X 10^5 cal/kg water) = 135,000 cal
- Energy to bring dry soil at 100°C to benzo(a)anthracene boiling point (435°C)
  (1 kg) (435°C-100°C)(200 cal/kg°C) = 67,000 cal
- Total energy to raise 1 kg of soil to boiling point of benzo(a)anthracene
  16,000 cal + 20,000 cal + 135,000 cal + 67,000 cal = 238,000 cal per kg soil

Condensation and condensate cooling system requirements

- To condense water
  (0.25 kg water)(5.4 X 10^5 cal/kg water)
  = -135,000 cal
- To cool water to 20°C
  (0.25 kg)(20°C - 100°C)(1000 cal/kg°C) = -20,000 cal

Due to the field set up with consequent energy recovery limitations, this energy will not be recovered.

Total energy requirement

- Total power required for 81,600 kg/day (90 ton/day) operation
  (81,600 kg/day)(238,000 cal/kg)(4.168 J/cal)
  (2.7778 X 10^{-7} kWhr/J)(1 day/24 hr) = ~
  942 kW

Assumptions:

- Feasibility study of site identified in (a) determined benzo(a)anthracene as the poly aromatic hydrocarbon compound of concern present in contaminated site soils which exceeded applicable cleanup goals.

- Data on the ability of low temperature thermal desorption to treat poly aromatic hydrocarbons reported the following results for an indirectly fired kiln: total poly aromatic hydrocarbons were reduced from approximately 4500 mg/kg to below 1.58 mg/kg and benzo(a)anthracene concentrations were reduced from 175 mg/kg to below 0.023 mg/kg.

- Contractor data exist indicating successful thermal treatment of similar contaminated material (benzo(a)anthracene) using unit capable of treating 81,600 kg/day (90 ton/day)

5. Process Residual Components. Determine the process residual components:

5.1 volume of water recovered from thermal desorption treatment

5.2 volume of organics (polyaromatics) recovered from thermal desorption treatment

5.3 flow rate to wastewater treatment plant

Given:

- 100.748×10^6 kg (111,000 ton) contaminated material

- 25% moisture content for contaminated material

- Average concentration of polyaromatics present in contaminated material 5000 mg/kg

- 54 months of operation

- density of water 1000 kg/m^3

Assumptions:

- Condensate from thermal desorption treatment contains 90% organics and 10% water by volume

- Wastewater flows to treatment plant during operation of thermal desorption system only

Solution:

- water present in soil
  (0.25 kg water/kg soil) (100.748 X10^6 kg soil)
  / (1000 kg/m^3) = 25,187 m^3 (6.66 X 10^6 gal) water

- condensate generated
  (0.005 kg organic/kg soil)(100.748 X10^6 kg)
  /(1000 kg/m^3) = 504 m^3 (133,000 gal) organics

- total liquid
  25,187 m^3 water + 504 m^3 organics
  = 25,691 m^3 (6.73 X 10^6 gal) liquid

- volume of organics recovered
  (504 m^3)/0.9 = 560 m^3 (148,000 gal) organics

- volume of water recovered
  25,691 m^3 - 560 m^3 = 25,131 m^3 (6.64 X 10^6 gal) water

- flow rate to wastewater treatment plant
  (25,131 m^3/1620 day) =~ 11 l/min (2.8 gal/min)